RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

	COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	67,139	81,344	58,582	68,437	75,056	76,799	78,665	Continuing	TBD
1010	Space Survivability & Surveillance	27,164	31,063	11,938	19,396	20,912	21,309	21,943	Continuing	TBD
4846	Spacecraft Payload Technologies	8,057	14,777	10,631	9,900	13,973	14,321	14,709	Continuing	TBD
5018	Spacecraft Protection Technology	0	0	4,620	3,948	2,552	2,351	2,157	Continuing	TBD
8809	Spacecraft Vehicle Technologies	31,918	35,504	31,393	35,193	37,619	38,818	39,856	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2003, Project 1010 is split, with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This PE focuses on four major areas. First, space systems protection develops technologies to understand, mitigate, and exploit effects of weather and geophysics environments on the design and operation of Air Force systems. Second, spacecraft payload technologies improve satellite payload operations by investigating advanced component and subsystem capabilities. Third, spacecraft vehicles, focuses on spacecraft platform, payload, and control technologies, and their interactions. The last major area, spacecraft protection, develops technologies for protecting U.S. space assets in potential hostile environments. Note: In FY 2002, Congress added $20.6 million ($1.3 million for Mixed Signal Very Large Scale Integrated (Circuits) for Space Vehicle Communication Subsystems, $8.5 million for the High-frequency Active Auroral Research Program (HAARP) Space Technology, $1.7 million for HAARP Electromagnetic Wave Gradiometer, $2.6 million for HAARP Incoherent Radar, $1.8 million for Satellite Simulation Took Kit, $3.0 million for Composite Cryogenic Fuel Tanks, and $1.7 million for Terabit).

(U) B. Budget Activity Justification

This program in Budget Activity 2, Applied Research, since it develops and determines the technical feasibility and military utility of evolutionary and revolutionary technologies.

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(U) C. Program Change Summary ($ in Thousands)

		FY 2001	FY 2002	FY 2003	Total Cost
(U)	Previous President's Budget	68,850	61,086	56,479	
(U)	Appropriated Value	69,487	81,686		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions		-342		
	b. Small Business Innovative Research	-1,650			
	c. Omnibus or Other Above Threshold Reprogram				
	d. Below Threshold Reprogram	-61			
	e. Rescissions	-637			
(U)	Adjustments to Budget Years Since FY 2002 PBR			2,103	
(U)	Current Budget Submit/FY 2003 PBR	67,139	81,344	58,582	TBD

(U) Significant Program Changes:
Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT: 1010

COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
1010 Space Survivability & Surveillance	27,164	31,063	11,938	19,396	20,912	21,309	21,943	Continuing	TBD

Note: In FY 2003, Project 1010 is split, with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This project develops the technologies to exploit the aerospace environment to the warfighter's benefit. The project focuses on characterizing the battlespace environment for realistic space system design, modeling, and simulation. It includes technologies to specify and forecast the environment from 'mud to sun' for planning operations and ensuring uninterrupted system performance and technologies to optimize space-based surveillance operations. Finally, it includes technologies that allow the opportunity to mitigate or exploit the aerospace environment for both offensive and defensive operations. Note: In FY 2002, Congress added $12.8 million ($8.5 million for the High-frequency Active Auroral Research Program (HAARP) Space Technology, $2.6 million for HAARP Incoherent Radar, and $1.7 million for HAARP Electromagnetic Wave Gradiometer).

(U) FY 2001 ($ in Thousands)

(U) $2,573 Developed technology to predict space environmental hazards, including solar disturbances and the earth's radiation belts, and the resultant disruptions of operational space systems. This technology leads to improved space system design, lifetime, and operational capabilities and aids in anomaly resolution. Developed technologies that control hazardous space particle populations in extreme environments resulting from natural or adversary actions. Began algorithm development for predicting solar disturbances impacting Air Force systems using all-sky images from new space-based detector system. Developed time-dose probability codes for improved space system design using data from new compact environment anomaly sensors. Began detailed design of active space particle control experiment to demonstrate the feasibility of space-based mitigation technologies.

(U) $9,171 Developed real-time infrared background clutter code, target detection techniques, and decision aids for application to space-based surveillance, laser weapons, and countermeasure systems, including detection of low-observable targets. Validated all-altitude background clutter prediction code through the use of space-based sensor data. Completed deployment aids and performance prediction models that minimize the operational impacts of atmospheric optical turbulence on laser weapons. Completed an assessment of advanced missile detection technologies that provide for the earliest detection of theater ballistic missiles in boost phase.

(U) $4,159 Developed artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting and space-based geolocation demonstrations. Communications/navigation outage forecasting will provide the warfighter with situational awareness and will permit operators to use alternate links or systems in times of outages.

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	PROJECT: 1010

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

Completed the fabrication and test of instrumentation for communication/navigation outage forecasting system demonstration. Developed algorithms for correcting ionospheric effects on geolocation accuracy.

(U) $1,587 Developed key satellite threat warning technologies and tools for on-board satellite use that detect, geolocate, and characterize acquired intentional and unintentional ground-based radio frequency and laser signals. Satellite threat warning technologies enable the warfighter to have increased knowledge of possible hostile acts directed at mission critical satellites and aid in satellite anomaly resolution. Designed key satellite protection technologies, such as geolocation algorithms, radio frequency antennas, and miniaturized sensor and processing electronics, for advanced satellite threat warning/attack reporting capabilities.

(U) $6,772 Expanded experimental research capabilities to characterize and control the physical processes produced in space with very high power radio waves at the High Frequency Active Auroral Research Program Alaska facility. Continued to further develop and test concepts for imaging underground structures and provide new radio-wave propagation modes via the generation of irregularities in the ionosphere. Continued the collection of diagnostic data to characterize the space weather environment. Investigated ionospheric Extremely Low Frequency/Very Low Frequency virtual antenna properties. Expanded the high frequency radio transmitter capability from 8-MHz to 10-MHz. Extended roads and installed additional diagnostic pads and instruments that reduce interference problems and enhance radio science capabilities.

(U) $2,902 Developed technologies that improve the survivability of space systems by specifying, forecasting, and mitigating the effects of the ionosphere and space radiation environment. Expanded the coverage of the Scintillation Network Decision Aid, which is a component of a global system for predicting the effects of ionospheric scintillation on communication and navigation systems. Developed advanced, space-borne sensors to detect hazards to spacecraft from space particles and chemical contamination. Developed advanced instrumentation and analysis techniques for real-time monitoring of solar activity and improved prediction of space environmental hazards.

(U) $27,164 Total

(U) FY 2002 ($ in Thousands)

(U) $2,469 Develop technologies for monitoring, predicting, and controlling space environmental conditions hazardous to DoD operational space systems. These technologies lead to improved space system design, lifetime, and operational capabilities and aid in anomaly resolution. Use simulations to assess technologies that control hazardous space particle populations in extreme environments resulting from natural or adversarial actions. Use all-sky images from space-based detector system to develop advanced algorithms for tracking system-impacting solar eruptions en route to Earth. Develop algorithms for short-term forecasting of solar flares, based on observations of plasma flow in solar active regions. Validate time-dose probability codes for space system design using data from compact environment anomaly sensors. Complete design of space particle

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BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 1010

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

control experiment. Construct dynamic radiation belt data assimilation and forecast models to predict energetic electron spacecraft hazards.

(U) $8,251 Develop real-time infrared backgrounds clutter code, spectral signature libraries, target detection techniques, and decision aids for application to space-based surveillance, laser weapons, and countermeasure systems, including detection of low-observable targets. Technologies lead to increased surveillance capability and to more effective operation of laser weapons and countermeasures systems. Develop global clutter specification model and dim-target detection techniques for advanced space-based surveillance systems. Incorporate global clutter model into all-altitude background prediction code and validate model with space-based data. Conduct field measurements to validate candidate concepts for earliest detection of theater ballistic missiles in boost phase. Test and validate decision aids and performance prediction tools for turbulence effects on laser weapon system performance. Validate global spectral signature libraries created from collected hyperspectral imaging data, and develop a modeling and simulation capability to predict the performance of surveillance functions under specified scene and atmospheric conditions.

(U) $6,280 Develop artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting and space-based geolocation demonstrations. This forecasting capability will support the warfighter through situational awareness, allowing operators to use alternate links or systems in times of outages. Integrate and validate the suite of ionospheric specification and forecast models for the Communications/Navigation Outage Forecast System (C/NOFS) Advanced Concept Technology Demonstration. Assemble the models with data-handling systems to construct the C/NOFS data center. Provide navigation reliability maps for geolocation requirements. Expand the ground-based network of ultra high frequency and L-band satellite links to provide worldwide outage specification and enhance the ground-based component of C/NOFS. Establish high latitude sites to monitor formation and motion of polar ionospheric patches.

(U) $1,387 Develop key satellite threat warning technologies and tools for on-board satellite use that detect, geolocate, and characterize acquired intentional and unintentional ground-based radio frequency and laser signals. Satellite threat warning technologies enable the warfighter to increase knowledge of possible hostile acts directed at mission critical satellites and aid in satellite anomaly resolution. Complete miniaturization of radio frequency attack reporting receiver. Incorporate results of attack reporting space flight test into system hardware and software. Investigate integrated attack reporting approaches.

(U) $8,418 Continue development of the High Frequency Active Auroral Research Program (HAARP) site transmitting and diagnostic instrument infrastructure. Install a permanent aircraft alert radar, a Very High Frequency ionosphere radio diagnostic, high frequency transmitter enhancements, and diesel power-plant reliability improvements. Provide facility management and environmental oversight. Conduct research programs to assess the viability of exploiting Extremely Low Frequency/Very Low Frequency waves generated in the ionosphere for detecting

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

and characterizing underground structures and for reducing charged particle populations in the radiation belts, which disrupt satellite systems and operations.

(U) $2,575 Develop a modular design and phased approach for an Incoherent Scatter Radar (ISR) diagnostic capability for the HAARP facility. Prepare the site infrastructure, including a gravel pad, access road, and power and optical fiber distribution networks. Acquire and install Incoherent Scatter Radar transmitting modules for engineering test purposes to validate the overall concept and design.

(U) $1,683 Investigate, enhance, and test electromagnetic radiometry technologies for the detection of underground structures using the High Frequency Active Auroral Research Program facility. Develop a miniature, rugged man-portable hardware system and an experimental airborne system, including improved detection algorithms, frequency agility, and remote data access. Conduct a study for a ground-based, unmanned random array detection system to exploit emerging technology.

(U) $31,063 Total

(U) FY 2003 ($ in Thousands)

(U) $1,364 Develop technologies for monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense (DoD) operational space systems. Validate algorithms for tracking solar plasma clouds to Earth and predicting onsets of adverse effects on DoD systems. Develop models and algorithms for propagation of solar/geomagnetic activity for spacecraft susceptibility to single event upsets. Complete initial dynamic radiation belt model with real-time data assimilation for spacecraft hazard forecasting.

(U) $4,716 Develop real-time infrared backgrounds clutter code, spectral signature libraries, target detection techniques, and decision aids for application to space-based surveillance, laser weapons, and countermeasure systems, including detection of low-observable targets. Validate background models with new experimental data and apply to surveillance system design trades and performance analyses. From field measurements determine trade space for space system for earliest detection of theater ballistic missiles in boost phase. Upgrade models of atmospheric turbulence sources and improve laser weapon performance prediction model of airborne and space-based systems. Develop advanced techniques to exploit hyperspectral data and validate hyperspectral performance modeling and simulation codes. Develop design requirements for space-based sensor to obtain sub-meter, high spectral resolution measurements of optical/infrared backgrounds for next-generation operational surveillance, target identification, and damage assessment systems.

(U) $5,858 Develop artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting and space-based geolocation demonstrations. Develop data processing software and hardware architecture for collecting and analyzing ground and space data to provide near-real-time nowcasts and forecasts of ionospheric hazards.

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

Validate nowcast and forecast predictions using ground and space-based experimental databases and incorporate results into forecast tool risk reduction. Improve techniques to track the motion of the highly structured plasma in the polar region, to enhance the reliability of ionospheric specification in high latitude theaters. Develop multi-scale algorithms to increase reliability of global ionospheric forecasts.

(U) $11,938 Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(U) Related Activities:
(U) PE 0305160F, Defense Meteorological Satellite Program.
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0305111F, Weather Systems.
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)

DATE: February 2002

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT: 4846

COST ($ in Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
4846	Spacecraft Payload Technologies	8,057	14,777	10,631	9,900	13,973	14,321	14,709	Continuing	TBD

(U) A. Mission Description

This project develops advanced technologies that enhance spacecraft payload operations by improving component and subsystem capabilities. The project focuses on three primary areas: (1) the development of advanced, space-qualified, survivable electronics, and electronics packaging technologies; (2) development of advanced space data generation and exploitation technologies, including infrared, Fourier Transform hyperspectral imaging, polarimetric sensing, and satellite antenna subsystem technologies; and (3) development of high-fidelity space simulation models that support space-based surveillance and space asset protection research and development for the warfighter. Note: In FY 2002, Congress added $3.1 million ($1.3 million for Mixed Signal Very Large Scale Integrated (Circuits) for Space Vehicle Communication Subsystems and $1.8 million for Satellite Simulation Tool Kit).

(U) FY 2001 ($ in Thousands)

(U) $2,351 Developed advanced space infrared technologies, hardened focal plane detector arrays, and quantum well infrared photodetectors (QWIPs) to enable acquisition, tracking, and discrimination of hot targets, as well as 'cold body' targets such as decoys, satellites, and midcourse warheads. Designed low temperature multi-color and low background infrared detectors and QWIPs, higher temperature infrared detectors, and higher performance radiation-hardened detectors. Continued experimental investigation of two-, three-, and multi-color detectors, and tunable and broadband gratings. Investigated future concepts for longer wavelength infrared detectors, mid-wavelength infrared detectors for higher temperature operation, and infrared detectors with optimal background-limited performance for stressing, low photon noise, and space backgrounds.

(U) $666 Developed hyperspectral imaging data exploitation methodologies for military remote sensing applications with the Fourier Transform HyperSpectral Imager (FTHSI). The FTHSI payload demonstrated the capability of providing the warfighter data concerning terrain categorization, feature extraction, geological formation mapping, and trafficability within an area observed from space. Completed analysis of the hyperspectral imaging data received from the FTHSI payload. Completed assembly of data images for target identification and image evaluation for commercial and military purposes.

(U) $3,859 Developed technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging for next generation high performance space electronics. Goals are decreased feature size, improved scalability, decreased size/weight/power, and radiation-hardness. Continued characterizing microelectronic materials and internal structures and apply results to improve fabrication processes. Designed next-generation low-power,

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(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

quantum-sized devices such as high-speed, radiation-hardened, low-power alternatives for space applications. Fabricated improved radiation-hardened nonvolatile memories, Fast Fourier Transform processors, optical sensors, and analog devices. Fabricated ultra-high density, low-power micro-electro-mechanical system (MEMS) device for evaluation in space environment. Fabricated smaller, lighter, lower power electronics packaging.

(U) $1,181 Developed modeling, simulation, and analysis (MS&A) tools for space-based surveillance systems, optical/infrared imaging space systems, large deployable space optics, and distributed satellite architecture payloads. MS&A tools provide data to validate research and development systems engineering level technology trade off decisions for space-based missions/campaign level assessments and for intelligent satellite system test beds. Integrated simulation architecture models using visual programming codes and commercial-off-the-shelf software to enhance fidelity of satellite constellation-level modeling. Interconnected satellite toolkit, spacecraft simulation toolkit, and weather and space simulation software into one framework. Evaluated multi-satellite constellations and distributed satellite cluster models in simulation test bed.

(U) $8,057 Total

(U) FY 2002 ($ in Thousands)

(U) $4,386 Develop advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads, throughout their trajectory. Develop cryogenic detector and read-out devices that will perform for extended periods of time under adverse natural and enhanced space environments. Develop and evaluate both broadband and narrow band detector devices and the appropriate low-noise, cryogenic read-out device and device architectures necessary for multi-band (two- and three-color) detection. Enhance device architectures for future space sensor concepts that include the need for radiation-hardness, radiation tolerance, longer wavelengths, higher operating temperatures and higher frame rates. Study next generation detection requirements for space, and explore and exploit potential infrared device solutions.

(U) $985 Develop hyperspectral imaging data exploitation methodologies for military imaging and remote sensing applications. Fourier Transform HyperSpectral Imager (FTHSI) and polarimetric sensing technologies will provide enhanced surveillance capability for future space-based sensor systems by improving the ability of the systems to discriminate military targets in various scenarios. Complete evaluation of the hyperspectral imaging system performance based on data received from the FTHSI payload. Develop technology and modeling for understanding the electro-optical/infrared polarimetric phenomenology.

(U) $4,388 Develop technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, MEMS devices, and advanced electronics packaging for next generation high performance space electronics. Expand microelectronic material

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		characterization to silicon-on-insulator and chalcogenide materials and apply radiation research and material defect analysis to improve device design. Fabricate and test monolithically integrated low power, silicon-based quantum-sized devices. Characterize new radiation-hardened nonvolatile digital memories, Fast Fourier Transform (FFT) processors, and optical sensors. Investigate design enhancements for ten-fold performance improvement for the memories and FFT processors. Fabricate nonvolatile analog memories. Establish a micro-electro-mechanical (MEMS) reliability test device for ground and space experiments. Investigate a chip-scale packaging system with optimized confinement features and coating for MEMS devices. Establish a non-volatile analog reconfigurable packaging architecture.
(U)	$963	Develop modeling, simulation, and analysis tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, large deployable space optics, and distributed satellite architecture payloads. Complete connection of satellite toolkit and spacecraft simulation toolkit. Extend simulation architecture to support flight software development and definition and conduct near-term flight test experiment.
(U)	$985	Develop advanced satellite antenna architectures and performance characterization tools for large, lightweight, modular space antennas. The advanced antenna architectures will improve the affordability and capability of antennas for space-based payload subsystems for Air Force surveillance and navigation efforts. Develop algorithms for performance characterization of modular phased-array antenna tiles. Build and test engineering models to simulate performance of phased-array antenna tiles and integrated antenna modules to include MEMS time delay units for phase control. Characterize performance of antenna tiles and modules and correlate results to model predictions; update models based on actual performance. Extend engineering models to simulate performance of the antenna tiles and integrated modules in a space environment in preparation for demonstration on a three microsatellite constellation space flight experiment.
(U)	$1,783	Develop core infrastructure components for a robust satellite simulation toolkit. The toolkit will enable cost-effective risk reduction for space technology programs via modeling and simulation of all phases from concept design through flight experiment and technology transition. Design and build software components for different user interfaces, connection to external hardware/software environments and simulations, and installation on inexpensive computer platforms. Add models and simulations of such space-based payload systems as radar, hyperspectral, and remote inspection sensors. Develop requirements for and initial designs of high-level models of space capability protection and counterspace technologies to be used for concept studies.
(U)	$1,287	Develop radiation-hard analog for mixed signal, Very Large Scale Integrated circuits for secure high-bandwidth intra-satellite and satellite-ground station communications. Radiation test and characterize state-of-the-art commercial mixed signal systems and elements to determine feasibility of adapting commercial technologies for military application. Design new radiation-hard analog elements.
(U)	$14,777	Total

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$3,808	Develop advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads throughout their trajectory. Evaluate two- and three-color detector and continue development of multi-color detectors and tunable and broadband gratings. Design and fabricate selected concepts for future longer wavelength infrared detectors and infrared detectors with optimal background-limited performance for stressing, low photon noise, and space backgrounds. Complete design study of next generation long and very long wavelength infrared detector concepts, including quantum wells and strained layer superlattices, as lower cost, higher performance alternatives to mercury cadmium telluride. Evaluate delivered radiation-hardened cryogenic multiplexers for lower background, space infrared detector arrays.
(U)	$901	Develop spectral sensing and data exploitation methodologies for military imaging and remote sensing applications. Continue development of technology and modeling for understanding the electro-optical/infrared polarimetric phenomenology. Evaluate initial polarimetric signature model capability and validate with measured data. Develop capability to integrate polarimetric models into modeling, simulation, and analysis (MS&A) for space-based surveillance applications.
(U)	$3,733	Develop technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical system (MEMS) devices, and advanced electronics packaging for next generation high performance space electronics. Continue silicon-on-insulator radiation research and enhance the switching speed and durability of the chalcogenide material by ten times for improved devices. Extend the design of the monolithically integrated low power, silicon-based quantum-sized devices to include non-traditional electronic materials. Continue to improve the speed of the radiation-hardened nonvolatile digital memories. Characterize the analog memories and enhance resolution to an eight-bit equivalent. Build space-qualified MEMS reliability test devices and chip-scale packages for ground and flight insertion. Build reconfigurable analog array packaging structures.
(U)	$1,189	Develop MS&A tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, large deployable space optics, and distributed satellite architecture payloads. Extend simulation architecture to support flight experiment ground-to-space segment simulation, post-experiment distributed signal processing, and post-experiment data validation. The architecture can then be used for objective system-of-systems assessment.
(U)	$1,000	Develop advanced satellite antenna architectures and performance characterization tools for large, lightweight, modular space antennas. Extend antenna architecture and algorithms developed for performance characterization of modular phased array antenna tiles to multi-beam, wide-bandwidth, multi-mode operation to include advanced low-noise amplifiers, integrated wide-bandwidth radiators, and active radio frequency manifold control technologies. Build and test engineering models to simulate performance of multi-beam, wide-bandwidth phased array antenna tiles and integrated antenna models.

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued
(U) $10,631 Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(U) Related Activities:
(U) PE 0603401F, Advanced Spacecraft Technology.
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT: 5018

COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
5018 Spacecraft Protection Technology	0	0	4,620	3,948	2,552	2,351	2,157	Continuing	TBD

Note: In FY 2003, Project 1010 is split, with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This project develops the technologies for protecting U.S. space assets in potential hostile environments to assure continued space system operation without performance loss in support of warfighter requirements. The project focuses on identifying and assessing spacecraft system vulnerabilities, developing threat warning technologies, and developing technologies to mitigate the effects of both intentional and unintentional threats.

(U) FY 2001 ($ in Thousands)

(U) $0 No Activity

(U) $0 Total

(U) FY 2002 ($ in Thousands)

(U) $0 No Activity

(U) $0 Total

(U) FY 2003 ($ in Thousands)

(U) $1,000 Develop key satellite threat warning technologies and tools for on-board satellite use to detect, geolocate, and characterize intentional and unintentional ground-based radio frequency (RF) and laser signals. Begin development of a high performance multiple threat sensors satellite protection system, improving technical performance of the sensor suite while still minimizing cost, power, and weight. Investigate integration of the miniature radio frequency receiver, laser detector, and ionospheric specification system with advanced reconfigurable processor electronics for the first generation system. Assess feasibility of using a single antenna for performing RF geolocation from a low-earth-orbit satellite. Investigate laser and RF false alarm rejection/mitigation and anomaly resolution and management techniques.

(U) $1,395 Develop miniaturized RF attack receiver. Complete post-test data and system performance analysis of risk reduction space experiment. Continue system integration for year-long space flight demonstration of advanced attack reporting system.

(U) $368 Develop techniques to exploit existing on-board satellite resources as first-line threat detection systems. Investigate use of systems on currently fielded or launch ready satellites for preliminary determination of RF/laser illumination or kinetic impact. Assess the use of telemetry, state-of-health data, and other appropriate data for event determination. Prepare for laboratory proof of concept demonstrations.

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	PROJECT: 5018

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

(U)	$1,857	Develop techniques for monitoring and assessing electromagnetic interference and compatibility between ultra-sensitive payload sensors for space systems which support space weather forecasting. Begin payload integration for the Communications/Navigation Outage Forecast System Advanced Concept Technology Demonstration. Design, develop, and test serial communications hardware and software for command and data handling spacecraft sub-system risk reduction for real-time space weather forecasting. Validate data compression techniques with payload sensor data and apply to space flight software for demonstrating space weather forecasting.
(U)	$4,620	Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(U) PE 0603401F, Advanced Spacecraft Technology.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT: 8809

COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
8809 Spacecraft Vehicle Technologies	31,918	35,504	31,393	35,193	37,619	38,818	39,856	Continuing	TBD

(U) A. Mission Description

This project focuses on seven major space technology areas: spacecraft platforms (e.g., structures, controls, power, and thermal management); space-based payloads (e.g., survivable electronics); satellite control (e.g., software for autonomous distributed satellite formation flying, signal processing, and control); modeling and simulation of space-based systems; satellite protection technologies (e.g., space environment effects, debris prediction, and threat warning/attack reporting); microsatellite technologies; and integrated experiments of advanced technologies for transition to planned systems (e.g., payload/platform/launch vehicle merging). Note: In FY 2002, Congress added $4.7 million ($3.0 million for Composite Cryogenic Fuel Tanks and $1.7 million for Terabit).

(U) FY 2001 ($ in Thousands)

(U) $2,990 Continued to develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells, lightweight batteries, and innovative power generation and storage concepts. Advance space platform subsystems will have more available power, longer operational lifetimes and increased operational range, and will be lighter and more affordable than current subsystems. Continued development of 35 percent efficient solar cells and thin film solar cells. Completed development of power cells using thermal to electric conversion technology and lithium ion and polymer batteries. Improved accuracy of cryocooler modeling tools, and identified mechanisms that limit operational life and degrade cryocooler subsystem performance.

(U) $7,104 Continued to develop technologies for advanced space platform structures such as spacecraft structural controls for vibration suppression, multi-functional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Whole spacecraft launch vibration suppression will enable precision pointing and sensing systems. Multi-functional and composite structures, with a higher level of integration and standardized interfaces will be reusable, lighter, and more affordable. Developed and completed vibration suppression algorithms. Continued development of multi-functional structures and complete integration techniques. Integrated and ground tested component subsystems of deployable large aperture optical arrays to identify performance of deployable optics.

(U) $1,552 Continued development of ground support and small satellite integration technologies for spaceborne platforms with advanced bus components and standardized interfaces for testing and demonstrating revolutionary high payoff mission hardware and mission-enabling technologies for space and near-space experiments. Conducted MightySat II.1 mission operations and began analyzing platform and stand-alone experiment operations.

(U) $13,695 Continued to develop microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. Fabricated components for

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(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

microsatellite, and completed detailed design of a three-unit flight constellation to demonstrate on-orbit formation flying, inter-satellite communications, distributed processing, and sparse aperture sensing.

(U) $1,741 Developed and demonstrated innovative methodology for aluminum aerostructure design. Developed a technical strategy to insert aluminum processing/manufacturing capability into early design and analysis. Identified specific opportunities to employ methodology on Air Force weapon systems. Demonstrated benefits on selected parts/assemblies to minimize cost while maintaining mechanical properties.

(U) $967 Developed low-cost, lightweight, leak-proof, linerless, non-metallic composite cryogenic tanks for reusable and small expendable launch vehicle applications. Designed, fabricated, and tested lightweight composite end-bosses and performed studies to address problems with delamination and micro-cracking.

(U) $3,869 Further developed and evaluated the world's first optically implemented Code Division Multiple Access wide-band network within the context of the Next Generation Internet. Assessed and demonstrated the inherent security capabilities as a means of enhancing information assurance at the transmission level.

(U) $31,918 Total

(U) FY 2002 ($ in Thousands)

(U) $4,386 Develop technologies for advanced space platform subsystems, such as cryocoolers, compact, high-efficiency solar power cells and arrays, and innovative power generation concepts. Continue identification of mechanical mechanisms for assessing cryocooler reliability. Develop improved models for low-temperature cryocooler regenerator performance. Complete a 32 percent efficient solar cell and a ten percent efficient thin-film solar cell.

(U) $8,877 Develop technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Ground test payload vibration suppression systems. Fabricate and characterize performance of multi-functional structure designs. Continue integration and ground test of component subsystems of deployable large aperture optical arrays. Start development of multifunctional bus structure for small spacecraft.

(U) $150 Complete development of ground support and small satellite integration technologies for spaceborne platforms with advanced bus components and standardized interfaces for testing and demonstrating revolutionary high payoff mission hardware and mission-enabling technologies for space and near-space experiments. Complete final analyses and reports on the MightySat II.1 platform and stand-alone experiment options.

(U) $17,436 Develop microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. Integrate and test microsatellite engineering model, and begin component fabrication of a three-unit flight constellation to demonstrate on-orbit formation flying, inter-satellite

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

communications, distributed processing, and sparse aperture sensing.

(U) $2,972 Develop low-cost, lightweight, leak-proof, linerless, non-metallic composite cryogenic tanks for reusable and small expendable launch vehicle applications. Investigate novel composite material systems and processes, focusing on manufacturability and scaling. Develop liquid oxygen (LOX) compatible material system, addressing both oxidation and ignition phenomena. Design, fabricate, and test full-scale tanks to determine the effectiveness of microcrack mitigation and LOX compatibility techniques on flight-representative articles.

(U) $1,683 Develop and evaluate the world's first optically implemented Code Division Multiple Access wide-band network within the context of the Next Generation Internet. Continue to assess and demonstrate the inherent security capabilities of different coding schema as a means of enhancing information assurance at the transmission level.

(U) $35,504 Total

(U) FY 2003 ($ in Thousands)

(U) $4,688 Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts. Continue to improve accuracy of cryocooler modeling tools and the identification of mechanisms that limit operational life and degrade cryocooler subsystem performance. Demonstrate a 35 percent efficient solar cell. Demonstrate production capacity for a ten percent efficient thin-film solar cell.

(U) $10,963 Develop technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Flight test payload vibration suppression systems. Continue performance characterization of multifunctional bus structure for small spacecraft.

(U) $15,742 Develop microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. Integrate and functionally test three microsatellites which will later form a three-flight unit constellation to demonstrate on-orbit formation flying, inter-satellite communications, distributed processing, and sparse aperture sensing.

(U) $31,393 Total

(U) B. Project Change Summary

Not Applicable.

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(U) C. Other Program Funding Summary ($ in Thousands)

(U) Related Activities:

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602102F, Materials.

(U) PE 0603311F, Ballistic Missile Technology.

(U) PE 0603401F, Advanced Spacecraft Technology.

(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.